

Chemical Engineering 436

Hints for Problem 11.11

1. First identify the controlled variable, manipulated variable, and disturbance variable.
2. Draw a block diagram similar to the one we did in class. My diagram has 9 boxes for transfer functions, including the unit conversion on the set point (K_m). Also, you will have a transfer function G_{TL} for the transport delay in the transfer line. The time delay box should be in the feedback loop, since it only represents the delay in measurement.
3. Note that the derivative portion of the controller is on the measurement rather than the error (we looked at this earlier in the semester). This becomes a separate transfer function in the controller from the PI part of the controller.
4. Steady state flow rates can be used to estimate the time delay for the transfer line.
5. Assume that the control valve dynamics can be fit with a first order transfer function. The gain of the transfer function can be found as follows:

$$K_v = \frac{\Delta q_A}{\Delta P_v} = \left. \frac{\partial q_A}{\partial P_v} \right|_{ss}$$

can be found by linearizing (about steady state) the relationship provided in the problem for the flow as a function of the signal pressure. The following mathematical relationship may be helpful:

$$\frac{d}{dx} (a^u) = (\ln a) a^u \frac{du}{dx}$$

The problem states that 1 minute is required for the valve to reach its new position. This information can be used to estimate the first order time constant. Assume that the new position is reached when it is somewhere around 99 to 99.5% of the way there (a nice round number results when you use 99.33%). Use the time form of the first order transfer function to determine a value for τ_v .

6. Both the disturbance variable and the manipulated variable are inputs to the process. Therefore, your dynamic process model can be used to find both G_p and G_d . Note that there is only *one output variable*. How many equations are needed in the model?
7. How does the concentration c_A change if the inlet stream is pure A?
8. Is the controller gain (K_c) positive or negative (i.e. reverse acting or direct acting)?
9. \bar{c} can be found from the steady-state material balance.
10. All of the transfer functions should have numerical values for the parameters except for the controller where K_c , τ_I , and τ_D remain unknown.
11. Do not put all of the individual transfer functions into one overall transfer function. We will do this type of problem next time.